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ABSTRACT

This unit is concerned with an overview of physical oceanography - the study of currents, tides, waves, and particle movements. The activities are designed for use by junior high school age students. Included in the unit are activities related to properties of sea water, physical phenomena of the ocean, and physical features of the ocean. Activities include background materials, suggested activities, and evaluation materials. (RH)

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WHAT IS PHYSICAL OCEANOGRAPHY?

A Learning Experience for
Coastal and Oceanic
Awareness Studies

Produced by

MARINE ENVIRONMENT CURRICULUM STUDY
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and

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Please send evaluations

of learning experiences

to

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TITLE: WHAT IS PHYSICAL OCEANOGRAPHY?

* CONCEPT: I.A.

I. The earth is a finite natural system.

A. THE PROPERTIES AND INTERACTIONS OF WATER, AIR, AND THE PHYSICAL EARTH SET THE LIMITS OF THE NATURAL SYSTEM.

** MARINE CONCEPT: 2.3

2. The oceans interact with the earth and its atmosphere.

2.3 ENERGY IS TRANSFERRED WHEREVER OCEAN AND LAND OR ATMOSPHERE MEET.

GRADE LEVEL: 7-9

SUBJECT: Science

PERIODS: Various

AUTHOR: Reiher

* From A Conceptual Scheme for Population-Environment Studies, 1973. Cost $2.50

** From Marine Environment Proposed Conceptual Scheme, 1973. No Charge.

Both conceptual schemes are available from Robert W. Stegner, Population-Environment Curriculum Study, 310 Willard Hall, University of Delaware, Newark, DE 19711

I. Introduction: What is oceanography?

Background information

The study of oceanography includes five areas of science. They are:

1. Physical oceanography - the study of currents, tides, waves and particle movements.

2. Chemical oceanography - the study of the elemental content of the ocean, nutrient concentration, and chemical reactions.

3. Geological oceanography - the study of bottom sediment types and their distribution, continental drift, undersea topography, and the processes by which ocean bottom features evolve.

4. Biological oceanography - the study of marine organisms and their distribution.

5. Meteorology - the interrelationship of weather, climate and oceans.

Student Activities related to the practical application of oceanography

Prepare a report on how man might "farm" the sea.
Prepare a report on methods of desalting the ocean water.

II. Properties of sea water:

A. Physical properties

Background information

There are three variables which affect the physical properties of sea water. They are temperature, depth, and salinity. At any specific location measuring the depth from a boat should present few difficulties. Soundings can be taken with a device called a sonic depth finder, which sends out signals in the form of sound waves. The depth of the water can be calculated by measuring the time it takes for a sound wave to reach the bottom and its echo to return, since the speed of sound in water at a given temperature is known.

The measurement of temperature and salinity is complicated by depth, season, and weather. Two compensations must be made in measurements of water temperatures below the surface.

1. The thermometer must be encased in pressure-resistant glass because the intense pressure at great depths could cause an unprotected thermometer to break.

2. A reversing thermometer, which will not change its temperature reading as it is elevated through warmer or cooler water, should be used.

For readings between the surface and 200 meters, temperatures may be recorded on a small glass slide within a bathythermograph as the instrument is dragged behind a ship.

Salinity is the total amount of solutes (dissolved solids) in a liter of seawater, expressed in parts per thousand (°/oo). The salinity of a given area may limit the kinds of marine organisms occurring there. The lowest salinity tolerated by marine organisms is 5 °/oo. Highest salinity tolerances are exhibited by the twenty species inhabiting Laguna Madre, Texas, which has a salinity of 50-80 °/oo. Estuaries, such as the Delaware Bay, have a gradient of salinities because the salt content is diluted by fresh water from rivers.

B. Chemical properties

Background information

The products of land erosion are carried by streams and rivers to the oceans. As a result of this process practically every element is found in seawater.

To determine the chemical composition of seawater water samples must be taken. A specially designed pressure-resistant container is lowered to the desired depth, filled and sealed at that depth. The bottle will then contain only water from the specified level. One such container is called the Nansen bottle.

Classroom activities related to physical properties of water

Demonstrate how water depth affects water pressure using the following experiment.

Make a water pressure gauge using two pieces of glass tubing, each 7 inches long, connected with rubber tubing to form a U-shape. Attach the U-shaped tube in an upright position to a board. Fill the tube to a depth of about 4 inches with water colored with dye, e.g., food coloring. This is a water pressure gauge.

Cover the mouth of a funnel with a sheet of thin rubber, and fasten it tightly with rubber bands or string. Connect the funnel to the water pressure gauge with a 15-inch length of rubber tubing.

Fill a tall glass container with water. Invert the funnel and lower it into the water just below the surface. Observe what happens in your pressure gauge. Lower the funnel to the bottom of the container of water. What happens at the increased depth? Measure the pressure at different depths. What is the relationship of depth to pressure?

Student activity

Prepare a report on what minerals man takes from the ocean bottom on a commercial basis.

III. Physical phenomena of the ocean

A. Tides

Background information

Tides result from the gravitational pull of the moon, and to some extent, the sun. Gravitational forces cause the waters of the oceans to form immense bulges on both sides of the earth. As the earth rotates beneath these bulges, the water level rises and falls alternately along coastlines; the rising and falling cycle is completed twice daily in most areas. The contours of a coastline and its relationship to the ocean basin beyond can modify the effect of the tide in a particular area. When the incoming water flows quickly into a narrow channel, the tide rises rapidly and noisily. This action is called a tidal bore. The tidal bore at the Bay of Fundy is so spectacular that it is world famous.

When the moon is full or new, the earth, sun and moon are in a straight line. At this time, the sun's gravitational pull, which is about half that of the moon's because of its great distance, combines with the moon's gravitational pull. The incoming tides then are at their highest and the outgoing tides are at their lowest. These tides are called spring tides. At the quarters of the moon, the sun and moon are at right angles to one another. The tides then are neither so high nor so low. These tides are called neap tides.

Classroom activity related to tides

Demonstrate the influence of the sun and the moon on ocean tides, as follows:

Using a large ball to represent the sun, a small globe to represent the earth, and a small ball to represent the moon, set the apparatus up as follows: On two opposite ends of a rubber band that is large enough to fit around the globe, tie one long piece of string and one short piece of string. Then tie the free end of the shorter piece of string to the ball representing the moon. Put the rubber band around the globe and tie the free end of the longer piece of string to the ball representing the sun. The rubber band represents the ocean and the strings represent the gravitational attractions of the moon and the sun.

Turn the globe so that the Atlantic Ocean faces the moon. Have someone hold the sun in place on the opposite side of the globe while you slowly pull the moon away from the globe.

What happens to the ocean?

How many high tides are there?

How many low tides?

Why is the high tide on the side of the moon higher than the high tide on the side of the sun?

What causes the low tides?

Next observe what happens when someone holds the moon in place while someone else slowly pulls the sun away from the globe.

Does the sun also cause tides?

Why does the sun have less effect than the moon on the ocean waters?

Observe carefully the size of the tides caused by the attraction of the moon. Then change the model so that the sun and moon are in line of the same side of the earth (as in spring tides). Tie another piece of string from the rubber band around the globe to something that will not move. Then gently pull the sun and moon away from the earth.

What happens to the ocean?

How do the sizes of these tides compare with the sizes of the tides you observed when you pulled the moon away from the earth?

Next arrange the model so that the sun and moon are at right angles to each other.

What kind of tides are caused by the attraction of the sun and moon when they are in this position?

This is how the sun and moon are arranged during neap tides.

Are they higher or lower than the spring tide arrangement?

B. Waves

Background information

The sun's heat generates currents in the atmosphere; winds create friction with the surface of the sea. The further wind blows across water, the higher the waves. As a wave advances, only the form of the wave advances, but not the water itself. Observe a buoy or a cork floating on the surface. As a wave approaches, the buoy or cork is lifted up by the first slope of the wave. It is carried up to the crest, or top, of the wave. The buoy or cork then slides down the slope into the trough, or bottom, of the wave. The buoy or cork stays at practically the same position as the wave passes over it. When waves approach the shoreline, the upward slope of the beach causes

the trough of the wave to touch bottom, slowing down the wave. The crest (top) is not slowed down and therefore falls forward. This phenomenon is similar to a boy sliding on a patch of ice. His feet and head are going at the same rate. However, when his feet reach the end of the patch of ice, his feet slow down and his head falls forward. So the crest of the wave falls forward, resulting in the breaking of the wave as we see it from the beach.

C. Currents

Background information

The following factors are responsible for ocean currents:

(1) solar heating;
(2) rotation of the earth (which also causes wind currents);
(3) presence of land masses which act as a barrier to water flow.

The sun's direct rays at the equator warm the water. Because of the warmth of the water and the earth's rotation, the level of the water is slightly higher at the equator. This, in turn, causes a slope down which the warm water flows toward the polar regions. The cold water from the polar regions flows toward the equator to replace the flowing warm water. This results in a constant flow as follows: warm, equatorial water cools as it travels toward the poles. This cooled water sinks and travels back to the equator where it is warmed and rises to the surface. This sinking and rising phenomenon forms a circular pattern which causes the ocean currents.

Student activities related to physical phenomena of the ocean:

Prepare a report on the blowhole at West Maui, Hawaii.

Prepare a report on tides in the Bay of Fundy.

Make diagrams showing what happens to water molecules during ocean waves.

Prepare a report on methods for mapping underwater currents.

Prepare a report on rip currents.

Prepare a report on the Coriolis effect and its influence on waves and currents.

Prepare a report on Swallow buoys.

Prepare a report on Tsunamis.

IV. Physical features of the oceans

A. Ocean floor

Background information

If there were no water covering the oceans it could readily be seen that the elevations and depressions of the ocean floor would resemble those found on land. Three main parts of the ocean are the continental shelf, continental slope and basin. The continental shelf, a gently sloping

underwater area, is really an extension of a continent. At ocean depths of about 500 feet, the ocean floor drops sharply, giving a steeply sloping area called the continental slope. Where this ends, the bottom of the ocean, called the basin, forms the floor.

Oceanic mud-slides probably form the canyons and valleys which dissect the irregular continental slopes. There are mountains in the ocean basins, one of which is called the Mid-Atlantic Ridge. A ridge is a long elevation of the deep sea-floor with steep sides and irregularities. Trenches, which are cracks in the ocean basin, are the lowest points on the earth. Some of the known trenches in the Pacific Ocean are: Aleutian Trench, Kuril Trench, Japan Trench, Mariana Trench, Mindanao Trench, New Hebrides Trench, Tonga Trench, Kermadec Trench, Middle America Trench and Peru-Chile Trench. The Romanche Trench is found in the Atlantic Ocean. Ridges and trenches are formed in the same way mountains are formed--a portion of the crust cracks under the pressure of the magma underneath, and liquid magma breaks through and solidifies. The magma sometimes carries mineral ores. The mineral particles, because they have an electric charge, tend to clump together to form nodules.

Oceanographers map the ocean floor using the technique of echo-sounding. Profiles of the ocean floor are obtained to enable research vessels to carry out geophysical and oceanographic research; to enable industries to mine such products as sulfur, oyster shells, oil and gas; and to map areas for the safe passage of surface and underwater vessels.

B. Sediment in the ocean

Background information

Sedimentation is the settling of fine particles. Ocean currents carry these particles away from land masses toward the interior of the ocean where they are deposited when currents slow down. Sedimentary rock is formed when the weight of sediments press underlying particles into compact layers. The layers of sediment and sedimentary rock are part of the earth's crust. The top layer of oceanic sediment contains sand, mud and marl (clay mixed with calcium carbonate). Below this is deep-sea muds and clay, and the bottom layer is sedimentary rock.

Student activities related to physical features of the ocean

Prepare a report on the Mid-Atlantic Ridge.
Prepare a report on at least two trenches.
Make a topographical map of the Atlantic Ocean floor.
Make a topographical map of the Pacific Ocean floor.
Report on the JOIDES program.
Prepare a report on methods for mapping the ocean bottom.
Build a model of the ocean floor using different materials for the layers and label the various formations and structures.
Take a core sample from the bottom of some body of water such as a pond, lake, stream or swamp. Use a small tube to take the core. Carefully empty the core on a piece of paper. Examine the material and describe and identify, if possible, its components.

Answers to Activities

p. 7 - Demonstration of how water depth affects water pressure:

As depth increases, water pressure increases. This relationship should be directly proportional, although the apparatus used here may not show this (because the air in the tubes and funnel may undergo a certain amount of compression.)

p. 8-9- Demonstration of the influence of the sun and the moon on ocean tides:

When the moon is pulled away from the globe, the Atlantic Ocean bulges.

Assuming that there is some tension on the rubber band from the sun, there will be two high tides and two low tides.

The high tide will be higher on the moon side because the moon has a stronger pull than the sun.

The low tides which form between the bulges are low water areas resulting from much water being pulled by the moon and sun to the bulges.

Yes, the sun also causes tides.

The sun has a smaller effect on the tides than the moon because it is so far away from the Earth.

When the sun and moon are lined up to one side of the Earth, the part of the ocean closest to the moon and sun bulges. (In reality, there would also be a bulge on the opposite side of the Earth due to the moon and sun pulling the Earth slightly away from the water on the far side.

The tides formed in this fashion should be as high as or slightly higher than they were before.

When the model is arranged so that sun and moon are at right angles to each other, the high tides are not as high as they were in the previous two arrangements. Here, the pull of the sun and moon cancel instead of reinforce each other.

The neap tides are not nearly so high or so low as the spring tides.

Pre and Post Test

I. Mix and match the following. Choose the best phrase in Column B which relates to each expression in Column A. Put the correct letter in each blank.

A	B
_____1. meteorology	A. the study of bottom sediments and their distribution, continental drift, undersea topography, and the processes by which bottom feature evolve.
_____2. physical oceanography	B. the study of the elemental content of the ocean, nutrient concentration, and chemical reactions.
_____3. geological oceanography	C. the interrelationship of weather, climate and oceans.
_____4. biological oceanography	D. the study of currents, tides, waves, and particle movements
_____5. chemical oceanography	E. the study of marine organisms and their distribution

II. Circle the correct word(s) which complete each sentence below.

1. Underwater sound velocity (increases, decreases) as water temperature decreases.

2. As water depth increases, water pressure (increases, decreases).

3. Ocean currents are caused by (circle three letters):
   a. large fish, whales, and ships
   b. solar heating
   c. earthquakes
   d. rotation of the earth
   e. presence of land masses which act as a barrier to water flow

4. The ocean floor can be mapped by using the technique of (echo sounding, continental drift).

III. Complete the following:

1. A gently sloping underwater extension of a continent is called a _____.

2. Three variables which affect the physical properties of sea water are a) _____ b) _____ and c) _____.

3. The three main parts of the ocean floor are the a) _____, b) _____ and c)_____.

IV. Diagrams

A. In the space below, draw 2 diagrams of the earth, sun and moon showing two ways of creating spring tides.

B. In the space below draw 2 diagrams of the earth, sun and moon showing two ways of creating neap tides.

Pre and Post Test Answers

I. 1. C.
2. D.
3. A.
4. E.
5. B.

II. 1. decreases
2. increases
3. b, d, e
4. echo sounding

III. 1. continental shelf
2. a) temperature
b) depth
c) salinity
3. a) continental shelf
b) continental slope
c) basin

IV. A.

IV. B.